ICAS MIZ Working Group Meeting (Virtual)

Programme

- **AEDT:** Australian Eastern Daylight Time (Syndey),
- **BST:** British Summer time (London),
- **EDT:** Eastern Daylight time (New York).

First Session: BST: Tuesday 15 October 2024

AEDT: Tuesday 15	Chair: Michael Meylan	
17:55 – 18:00	Welcome remarks.	Michael Meylan
18:00 – 18:25	A contrast in sea ice drift and deformation between winter and spring in the Antarctic marginal ice zone	Marcello Vichi
18:30 – 18:55	Integrated dynamics and thermodynamics modelling of sea ice and waves in the Antarctic marginal ice zone	Rutger Marquart
19:00 – 19:30	Break	
19:30 – 19:55	Estimation of Antarctic sea ice thickness through observation of wave attenuation	Alberto Alberello
20:00 – 20:25	Very rapid sea ice loss events and the role of Arctic cyclones	Jake Aylmer

BST: Tuesday 15	Chair: Michael Meylan	
7:55 – 8:00	Welcome remarks.	Michael Meylan
8:00 – 8:25	A contrast in sea ice drift and deformation between winter and spring in the Antarctic marginal ice zone	Marcello Vichi
8:30 – 8:55	Integrated dynamics and thermodynamics modelling of sea ice and waves in the Antarctic marginal ice zone	Rutger Marquart
9:00 – 9:30	Break	
9:30 – 9:55	Estimation of Antarctic sea ice thickness through observation of wave attenuation	Alberto Alberello
10:00 – 10:25	Very rapid sea ice loss events and the role of Arctic cyclones	Jake Aylmer

EDT: Tuesday 15	Chair: Michael Meylan	
2:55 – 3:00	Welcome remarks.	Michael Meylan
3:00 – 3:25	A contrast in sea ice drift and deformation between winter and spring in the Antarctic marginal ice zone	Marcello Vichi
3:30 – 3:55	Integrated dynamics and thermodynamics modelling of sea ice and waves in the Antarctic marginal ice zone	Rutger Marquart
4:00 – 4:30	Break	
4:30 – 4:55	Estimation of Antarctic sea ice thickness through observation of wave attenuation	Alberto Alberello
5:00 – 5:25	Very rapid sea ice loss events and the role of Arctic cyclones	Jake Aylmer

Second Session: AEDT: Wednesday 16 October 2024

AEDT: Wednesday 16	Chair: Noa Kraitzman	
9:00 – 9:25	"Where the MIZ really is": The first fine-scale climatology of the Antarctic wave-affected marginal ice zone	Alex Fraser
9:30 – 9:55	Sea ice in WAVEWATCH III: an intercomparison project	Fabien Montiel
10:00 – 10:30	Break	
10:30 – 10:55	Sea Ice Multiscale Modeling and Data Assimilation	Quanling Deng
11:00 – 11:25	Analysis of the Antarctic Marginal Ice Zone Based on Unsupervised Classification of Standalone Sea Ice Model Data	Luke Bennetts

BST: Tue 15 – Wed 16	Chair: Noa Kraitzman	
23:00 – 23:25	"Where the MIZ really is": The first fine-scale climatology of the Antarctic wave-affected marginal ice zone	Alex Fraser
23:30 – 23:55	Sea ice in WAVEWATCH III: an intercomparison project	Fabien Montiel
0:00 – 0:30	Break	
0:30 – 0:55	Sea Ice Multiscale Modeling and Data Assimilation	Quanling Deng
1:00 – 1:25	Analysis of the Antarctic Marginal Ice Zone Based on Unsupervised Classification of Standalone Sea Ice Model Data	Luke Bennetts

EDT: Tuesday 15	Chair: Noa Kraitzman	
18:00 – 18:25	"Where the MIZ really is": The first fine-scale climatology of the Antarctic wave-affected marginal ice zone	Alex Fraser
18:30 – 18:55	Sea ice in WAVEWATCH III: an intercomparison project	Fabien Montiel
19:00 – 19:30	Break	
19:30 – 19:55	Sea Ice Multiscale Modeling and Data Assimilation	Quanling Deng
20:00 – 20:25	Analysis of the Antarctic Marginal Ice Zone Based on Unsupervised Classification of Standalone Sea Ice Model Data	Luke Bennetts

Third Session: EDT: Wednesday 16 October 2024

AEDT: Thursday 17	Chair: Ian Eisenman	
2:00 – 2:25	Developments in modeling wave-sea ice interactions in an Earth System Model	Cecilia Bitz
2:30 – 2:55	Developments in modeling wave-sea ice interactions in an Earth System Model	Isaac Klapper
3:00 – 3:30	Break	
3:30 – 3:55	Melting processes in the marginal ice zone inferred from floe size distributions measured with a drone in the southern Sea of Okhotsk	Takenobu Toyota
4:00 – 4:25	Wave momentum and energy transfers observed in the MIZ	Jim Thomson

BST: Wednesday 16	Chair: Ian Eisenman	
16:00 – 16:25	Developments in modeling wave-sea ice interactions in an Earth System Model	Cecilia Bitz
16:30 – 16:55	Developments in modeling wave-sea ice interactions in an Earth System Model	Isaac Klapper
17:00 – 17:30	Break	
17:30 – 17:55	Melting processes in the marginal ice zone inferred from floe size distributions measured with a drone in the southern Sea of Okhotsk	Takenobu Toyota
18:00 – 18:25	Wave momentum and energy transfers observed in the MIZ	Jim Thomson

EDT: Wednesaday 16	Chair: Ian Eisenman	
11:00 – 11:25	Developments in modeling wave-sea ice interactions in an Earth System Model	Cecilia Bitz
11:30 – 11:55	A Mathematical Model of Microbially-Induced Convection in Sea Ice	Isaac Klapper
12:00 – 12:30	Break	
12:30 – 12:55	Melting processes in the marginal ice zone inferred from floe size distributions measured with a drone in the southern Sea of Okhotsk	Takenobu Toyota
13:00 – 13:25	Wave momentum and energy transfers observed in the MIZ	Jim Thomson

Abstracts

Speaker: Marcello Vichi
Title: A contrast in sea ice drift and deformation between winter and spring in the Antarctic marginal ice zone
Abstract: Two ensembles of buoys, deployed in the marginal ice zone (MIZ) of the north-eastern Weddell Sea region of the Southern Ocean, are analysed to characterise the dynamics driving sea ice drift and deformation during the winter-growth and the spring-retreat seasons of 2019. The results show that although the two buoy arrays were deployed within the same ice types, their trajectory patterns were vastly different. This indicates a varied response of sea ice in each season to the local winds and currents. Analyses of the winter data showed that the Antarctic Circumpolar Current modulated the drift near the sea ice edge. This led to a highly energetic and mobile ice cover, characterised by free-drift conditions. The resulting drift and deformation were primarily driven by large-scale atmospheric forcing, with negligible contributions due to the wind-forced inertial response. On the other hand, the spring drift was governed by the inertial response as increased air temperatures caused the ice cover to melt and break up, promoting a counterintuitively less wind-driven ice–ocean system that was more dominated by inertial oscillations. In fact, the deformation spectra indicate a strong decoupling to large-scale atmospheric forcing. Further analyses, extended to include the deformation datasets from different regions around Antarctica, indicate that, for similar spatial scales, the magnitude of deformation varies between seasons, regions, and the proximity to the sea ice edge and the coastline. This implies the need to develop rheology descriptions that are aware of the ice types in the different regions and seasons to better represent sea ice dynamics in the MIZ.

Speaker: Rutger Marquart
Title: Integrated dynamics and thermodynamics modelling of sea ice and waves in the Antarctic marginal ice zone
Abstract: In this study, we extend the model by Marquart et al. (2021, 2023), by coupling the dynamics and thermodynamics in the Antarctic MIZ, consisting of agglomerated ice floes and interstitial grease ice. Our particular focus is on bridging the gap between small-scale processes and the larger-scale processes resolved by current numerical ocean-sea ice models. The goal is to predict the spatial and temporal evolution of sea ice variables, such as thickness and viscosity, considering both the dynamic and thermodynamic effects. Two objectives are established to achieve this. The first objective involves investigating how mechanical properties of sea ice vary in response to passing waves, considering increased spatial and temporal scales by utilizing the synthetic aperture radar (SAR) imaging technique. The second objective entails the integration of the revised existing thermodynamic model by Tedesco et al. (2009) into the proposed model in OpenFOAM, implementing a coupling approach that addresses the distinctive features of the two ice types in question.

Speaker: Alberto Alberello
Title: Estimation of Antarctic sea ice thickness through observation of wave attenuation
Abstract: The Close-Packing model – a physically based model for wave attenuation in sea ice – is used to infer sea ice thickness from wave observations collected in the Antarctic marginal ice zone during the PIPERS experiment. The model, calibrated for Arctic conditions, predicts ice thickness in good agreement with independent satellite measurements. The calibrated Close-Packing model, which is expressed in a simple monomial form, appears to have broad validity and, therefore, can be a suitable option for operational purposes.

Speaker: Jake Aylmer
Title: Very rapid sea ice loss events and the role of Arctic cyclones
Abstract: Very rapid Arctic sea ice loss events (VRILEs) are extreme changes in regional sea ice extent on times scales of a few days to weeks. They are poorly represented in operational forecasts, suggesting shortcomings in the representation of sea ice processes particularly in the marginal ice zone (MIZ). Studies have suggested cyclones could play a major role in generating VRILEs, often based on extreme cases such as the "Great Arctic Cyclone" of August 2012. Here, we analyse the extent to which VRILEs are associated with cyclones in a 45 year atmosphere-forced sea ice simulation. We use a version of the CICE sea ice model enhanced with new MIZ parameterisations including variable form drag and prognostic floe size distribution. Of the circa 500 simulated VRILEs, only about 60% are associated with the presence of a cyclone at all, and there is little impact on VRILE magnitudes compared to non-cyclone cases. Our results suggest that the importance of cyclones for the occurrence of VRILEs may have been previously overestimated.

Speaker: Alex Fraser
Title: "Where the MIZ really is": The first fine-scale climatology of the Antarctic wave-affected marginal ice zone
Abstract: The marginal sea ice zone (MIZ) is defined as the region where the open ocean influences sea ice properties, primarily through wave-ice interactions. Antarctic MIZ width is inadequately/inaccurately quantified by applying thresholds to satellite-derived maps of sea-ice concentration. While laser altimetry can provide accurate snapshots of the wave-affected MIZ, it is limited by cloud cover, complicating automation. We address this limitation by refining radar altimetry-based techniques. By examining changes in waveform properties from the open ocean to consolidated pack ice, we retrieve the along-track wave-affected MIZ width in an automated fashion. This method is applied to AltiKa Ka-band radar altimeter data, generating a daily MIZ-width product from 2013 to now. We validate this approach by comparing output with ICESat-2 laser altimetry-based MIZ width measurements. Our analysis reveals, for the first time, the regionality and seasonality of the wave-affected MIZ climatology. This new technique offers a simple, robust method for determining the wave-affected MIZ width and can potentially be applied to earlier satellite datasets, enabling creation of a new climatology for this critical physical sea ice zone. Our product will be available to assess the role of the changing MIZ in the recent rapid decline of Antarctic sea ice.

Speaker: Fabien Montiel
Title: Sea ice in WAVEWATCH III: an intercomparison project
Abstract: WAVEWATCH III (WW3) model hindcasts of the PIPERS wave buoys deployment in the 2017 ice-covered Ross Sea were conducted for all existing parameterizations of the sea ice damping source term. Default values of the parameters were used for each parameterization. A detailed comparison of wave spectra showed that WW3 typically underestimates wave attenuation, especially at high frequency and at high ice concentration. A bias in dispersion properties was also identified. Our analysis suggests none of the existing parameterizations of ice-induced damping in WW3 are appropriate at this stage, noting that parameter optimisation may improve model fit.

Speaker: Quanling Deng
Title: Sea Ice Multiscale Modeling and Data Assimilation
Abstract: This talk will focus on sea ice modelling and data assimilation, primarily drawn from our two recent research papers "Particle-Continuum Multiscale Modeling of Sea Ice Floes" and "LEMDA: A Lagrangian-Eulerian Multiscale Data Assimilation Framework." These works serve as the cornerstone of our discussion, highlighting the complexities of sea ice dynamics across multiple scales and model coupling with such as ocean dynamics. I will start by presenting some quick facts about Arctic and Antarctic sea ice floes followed by a quick overview of the major sea ice continuum and particle models. Then I will introduce our multiscale model and present a data assimilation framework based on this multiscale model. I will close the talk by briefly discussing our current endeavours in integrating machine learning tools into the data assimilation process within the context of multiscale sea ice modelling. This is based on joint work with Nan Chen, Sam Stechmann, and Jiuhua Hu (all from UW-Madison).

Speaker: Luke Bennetts
Title: Analysis of the Antarctic Marginal Ice Zone Based on Unsupervised Classification of Standalone Sea Ice Model Data
Abstract: This study uses unsupervised statistical clustering of sea ice data simulated by a global sea ice model (standalone CICE6 combined with a wave propagation module and prescribed ocean) to address the challenge of separating the marginal ice zone from the inner ice pack in sea ice data sets. The method identifies a marginal ice zone with the desired characteristics and floe size is shown to be the key variable in the classification. Simulated marginal ice zone widths are similar to those derived from satellite observations of wave penetration distances, but contrast with those using the standard 15%–80% areal sea ice concentration proxy, particularly during austral winter. The simulated marginal ice zone is found to undergo a seasonal transition due to new ice formation in winter, increased drift in spring, and increased rates of wave-induced breakup and melting in summer. The understanding gained from the study motivates incorporation of wave and floe-scale processes in sea ice models, and the methods are available for application to outputs from high-resolution and coupled sea ice–ocean–wave models for more detailed studies of the marginal ice zone (in both hemispheres).

Speaker: Cecilia Bitz
Title: Developments in modeling wave-sea ice interactions in an Earth System Model
Abstract: The sensitivity of sea ice to climate forcing has been found to be too weak among CMIP models. A possible reason is the absence of wave-ice coupling in models. Ocean surface waves are becoming more common in the newly opened seas as sea ice loss exposes the ocean directly to winds that produce surface waves. I'm part of a team that developed and added a floe-size distribution to CICE6. The code accounts for wave fracture by waves, floe welding under freezing conditions, and floe size dependent lateral melt. We've added an additional parameterization to WWIII that accounts for the evolving sea ice concentration, thickness and floe sizes on wave attenuation in sea ice. We've also improved the numerics of the source terms in the wave energy equation, resulting in a far more accurate solution of wave attenuation in sea ice. The latest modification includes floe fracturing under sea ice deformation and new methods to treat floe fracture under ocean surface waves. I'll discuss these new developments and their consequences in a fully-coupled simulation of an Earth System Model in terms of the wave spectrum in sea ice, the floe size distribution, ice-albedo feedback and the sea ice cover's sensitivity to winds.

Speaker: Isaac Klapper
Title: A Mathematical Model of Microbially-Induced Convection in Sea Ice
Abstract: Sea ice is an interestingly complicated material consisting of a mixture of solid ice and liquid phases which are coupled by thermodynamic considerations. It also is a platform for microbial life, lots of it in fact, that uses the ice as a sort of shelter though eventually becoming part of the local food chain. A model will be presented that hypothesizes how, in turn, the resident microbial population might impact sea ice properties, brine channel structure in particular, via influence on brine osmolarity.

Speaker: Takenobu Toyota
Title: Melting processes in the marginal ice zone inferred from floe size distributions measured with a drone in the southern Sea of Okhotsk
Abstract: Floe size distributions (FSD) of relatively small ice cakes (flat sea ice less than 10 m across) were first estimated in the southern Sea of Okhotsk using a drone in mid-February 2020. Since lateral melting plays a significant role in the retreating rate of the seasonal ice zones (SIZ), FSD is expected to provide implications about lateral melting. However, the limited observations of FSD for small sea ice has hampered it so far. Relatively warm conditions during the observation period allow us to estimate the lateral melting processes by combining FSD measurements with meteorological reanalysis dataset. The analysis of about 12,000 floes within about 2x104 m2 area revealed that while FSD basically showed scale invariance for floes larger than 0.8 m, consistent with previous studies, rapid melting were indicated from the FSD for floes less than 0.8 m. The real melting processes are discussed based on the results.

Speaker: Jim Thomson
Title: Wave momentum and energy transfers observed in the MIZ
Abstract: The rapid decline of summer sea ice cover in the Western Arctic has been accompanied by a dramatic increase in the sea state of the region. Ocean waves are now more common throughout the region, including multiple energetic swell events each summer. These waves interact with the sea ice and help to both form and define the expanding Marginal Ice Zone (MIZ) of the Western Arctic. A key mechanism is the attenuation of surface waves, which is related to turbulence at the ice-ocean interface. This seminar will review recent work to observe the transfer of wave momentum and energy entering the MIZ.